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EMPLACEMENT AND STEMMING LOAD MEASUREMENTS; PROJECT CANNIKIN

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Army Engineer Waterways Experiment Station

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The Waterways Experiment Station (WES) participated in Project CANNIKIN, Amchitka Island, Alaska, during the period of September 1970 to November 1974. Lawrence Livermore Laboratory (LLL), Livermore, California, was provided support with instrumentation and personnel to monitor continuously the emplacement and stemming load for the CANNIKIN nuclear experiment. Three gages were prepared by mounting strain gages on 4-ft-long, 10-3/4-in., P110 pup joint steel casing. Each gage was calibrated in the laboratory by pull-testing to a load in excess

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of expected field loads and recording the gage output versus load. During the field operation, pup joint gages were placed in the device emplacement casing string at the following locations below the collar at final seating: 5305 ft, 2970 ft, and 72 ft. After connecting each gage in the casing string, the gage output was monitored as it was lowered downhole. The bottom gage provided critical loading information that was used in determining the rate of lowering of the device through several tight or misaligned areas. All three gages were monitored during the stemming operation providing pertinent information regarding stemming load tranferred to device canister and casing string.

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PREFACE

The work reported herein was conducted by personnel from the Concrete Laboratory of the U. S. Army Engineer Waterways Experiment Station (WES). The work was accomplished on Amchitka Island, Alaska, in connection with Project CANNIKIN. The work was conducted for Lawrence Livermore Laboratory (LLL), Livermore, California, under the sponsorship of the Atomic Energy Commission. It was accomplished during the period of September 1970 to November 1971 under the general supervision of Mr. Bryant Mather, Chief, Concrete Laboratory, and under the direct supervision of Mr. R. V. Tye, Jr., Chief, Engineering Sciences Division, and Billy R. Sullivan, Chief, Engineering Physics Branch. Project Engineer for these measurements was Mr. Donnie L. Ainsworth. This report was prepared by Mr. Ainsworth with the assistance of Mr. Dale Glass.

Directors of WES during this investigation and the preparation and publication of this report were COL Levi A. Brown, CE, BG Ernest D. Peixotto, CE, and COL G. H. Hilt, CE. Technical Director was Mr. F. R. Brown.

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CONTENTS

CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
inches	2.54	centimetres
feet	0.3048	metres
pounds	0.4536	kilograms
pounds, force	4.4482	newtons

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Nuclear devices that are placed at large vertical distances below the surface are usually lowered on standard API pipe utilizing a drill rig. Upon reaching final position, the device, cables, etc., are supported by the emplacement casing which is attached to the strongback at the surface. The casing used for lowering the device, electrical cable, and any other hardware in the string usually has a safety factor of three on the yield strength for total downhole load. In general, the casing is pull tested to a load 1-1/2 times the total downhole load.

It has been theorized that all of the stemming material load is not transferred to the casing. As material is added the load on the casing increases but not necessarily proportional to the actual weight of the stemming material. It is believed that the stemming material bridges between the side wall and the casing and, therefore, supports some of the load. However, even though this has been the assumption, the casing is always designed to support a load in excess of total weight of device, casing, cables, and stemming material.

WES was requested by Lawrence Radiation Laboratory (LRL), Livermore, California, in their letter of 16 September 1966, to design and calibrate an experiment for measuring the Project STERLING, Station 1A granular stemming load. Sixteen SR-4 strain gages were mounted around the center of a 3-ft section of standard 9-5/8 in., J55, 40-lb long-thread casing. The gages were connected to form two complete load cell circuits each consisting of four active gages and four temperature compensating gages.

The casing load cells were calibrated and later installed in the 2700-ft casing string 30 ft below the strongback. The indication from the load cells was that approximately 22 percent of the material weight added in the annulus and 48 percent of that added in the 9-5/8-in. casing were transmitted to the casing.

One 7-in.-diameter calibrated strain gaged pup-joint was utilized on project GASBUGGY in November and December 1967. This load cell was calibrated in the laboratory to 360,000 lbf and measured a maximum of 224,000 lb in the field experiment. The pup-joint was located approximately 30 ft below the collar in a 4250-ft casing string. WES did not obtain the actual weight of the material added; therefore, a determination of the percent of stemming material weight transmitted to casing was not accomplished.

Three 9-5/8-in.-diameter calibrated strain gage pup joints were used on project FAULTLESS in January 1968. These were located at 3061 ft, 1498 ft, and 50.7 ft below the collar. The maximum loads recorded were 50,000 lb compression, 151,000 lb tension, and 286,000 lb tension, respectively. The load cells were calibrated in the laboratory to 200,000 lbf both in tension and compression, 220,000 lbf tension, and 340,000 lbf tension, respectively.

Three 10-3/4 in. pup joints were also prepared and calibrated for project ADAGIO; however, the project was cancelled prior to field operation. The pup joints and other associated equipment and hardware were set aside for use on other experiments if applicable.

1.2 PURPOSE AND SCOPE

The work described in this report was accomplished specifically for the purpose of support of the Lawrence Livermore Laboratory (LLL) emplacement and stemming operation for Project CANNIKIN. This report will discuss the pup joint fabrication, calibration, and field installation, as well as the measurements obtained.

CHAPTER II

PROCEDURE

2.1 EXPERIMENTAL METHOD

The Engineering Physics Branch, Concrete Laboratory, USAE Waterways Experiment Station (WES), was requested by Lawrence Livermore Laboratory, Livermore, California, to design an experiment to measure the emplacement and stemming loads at three stations on the emplacement casing for Project CANNIKIN, Amchitka Island, Alaska. Project CANNIKIN was a 5 megaton underground nuclear test detonated in November 1971. The device was positioned approximately 5875 ft beneath the surface and was lowered and supported from the surface by 10-3/4 in. API casing. The 90-in.-diameter borehole was cased with 54-in.-diameter casing.

2.1.1 Gage Design. The gages designed for this work were similar to those used by WES on Projects STERLING, GASBUGGY, and FAULTLESS. Each gage was designed around a 4-ft-long, 10-3/4 in., P-110 pup joint which was to become an integral part of the emplacement casing string. Each gage consisted of 16 wire strain gages mounted around the circumference of the pup joint forming two full four arm temperature compensated bridge networks. Figure 2.1 is a photograph of typical gage installation around the casing. One 4-conductor shielded Belden No. YR 7869 cable was used to provide power to both bridges and another identical cable to monitor outputs.

The strain gages and solder joints were waterproofed with successive applications of Gagekote No. 1, Gagekote No. 5, and Gagekote No. 2,

To protect the gages, connecting wires, and terminals, a dust-tight 20 gage sheet metal shield was installed around the gage area and was held in place by welding to the sleeve installed on the end of the pup joint. The shield was sealed with RTV silastic to prevent dust and moisture from migrating to the gages.

2.1.2 Gage Calibration. The two pup joints for the lower stations weighed 51-lb per ft and the one for the top station weighed 71.1-lb per ft. The two 51-lb per ft strain gaged pup joints were calibrated by pulling to 440,000 lbf with the 440,000-lbf Universal Loading Machine at the WES Concrete Laboratory (CL). Figure 2.2 is a photograph of a pup joint installed in the loading machine. The calibration instrumentation is also shown in this photograph. Figure 2.3 is a photograph of the hardware utilized in the pulling operation.

Calibration data were obtained every 20,000 lbf from 0-400,000 lbf tension and from 0-100,000 lbf compression for the bottom pup joint. Figure 2.4 is a plot of the calibration data load versus bridge output. This plot shows that the load cell has a linear response over the range tested. A similar calibration curve was obtained for the middle pup joint over the range of 0-440,000 lbf tension and is shown in figure 2.5.

The 71.1-lb per ft top pup joint was shipped by LLL to Los Alamos, New Mexico, and was strain gaged and calibrated by WES personnel at the Zia Company facility at Los Alamos. This heavier joint was calibrated to 1,500,000 lbf in the Zia Company's pull testing apparatus. The testing apparatus was operated by Zia personnel. Figure 2.6 is a plot of load versus bridge output for this pup joint.

All three pup joint load cells were calibrated with the cable used in the actual field operation. This alleviates the concern for the effects of long cable lengths on the response of the measuring system. Calibration steps were obtained by shunting known resistances across an active arm of the bridge denoting the bridge output voltage change and relating this change to simulated load. These calibrations are shown in figures 2.4, 2.5, and 2.6.

2.2 Instrumentation. Each full bridge network was powered and conditioned by a Model SAM-1, Sensor Analog Module, manufactured by MB Electronics. The unit contains a 0-25 volt DC transducer power supply, amplifier, and a four step bridge calibrator. The output of the conditioning unit was connected to the input of a Westronic multiple point recorder in parallel with a Model 8100A Fluke digital multimeter.

The bridge power voltage was adjusted to 10 volts for each load cell and the amplifier was adjusted to give a full scale deflection of the recorder for a load in excess of that expected. Full scale deflections were set as follows for the respective load cells: top, 1,000,000 lb; middle, 800,000 lb; and bottom, 500,000 lb.

2.3 Field Installation. The gages were installed in the casing string as follows: the lower pup joint was installed on 14 October 1971 and was located such that at final seating it was approximately 5305 ft below the collar; the middle pup joint was installed on 19 October 1971 at a depth of approximately 2970 ft below the collar; and the top pup joint was installed on 26 October 1971 at a depth of approximately 72 ft below the collar. After the hermetically sealed cable connections were

made near the installed instrumented pup joint, the connectors were coated with an RTV silastic adhesive and wrapped with electrical tape.

2.4 Field Measurements. Because of anticipated long emplacement duration, it was originally planned to begin continuous monitoring of load after the emplacement string was landed on the strongback. However, upon arrival on Amchitka, WES personnel were consulted by Messrs. Petrie and Lake regarding the possibility of using the lower WES pup joint for the additional task of determining the load changes due to friction on the device and diagnostic cannister during the emplacement operation. WES determined that at least a minimum of 500-lb load change could be determined. It was then decided that WES should monitor this channel continuously and maintain intercom contact with the LLL representative in charge of the downhole operation, especially while moving through the critical locations.

CHAPTER III

RESULTS

3.1 INSTRUMENT AND GAGE PERFORMANCE

During the emplacement operation, WES monitored the in-place load cells continuously. One channel of the lower load cell was used to monitor the load change on the cannister. Using a digital multimeter, load changes as little as 10 lb could be observed; however, while the emplacement casing was moving, mechanical vibrations caused dynamic oscillations with amplitudes of several hundred pounds. Utilizing a strip chart continuous recorder, WES personnel were able to detect any instantaneous loading of the device cannister and, thereby, aid in determining the rate of lowering the device through several critical or tight locations. Figure 3.1 is a typical strip chart of load versus time curve.

Both gages at each of the three stations were monitored during the stemming operation. The emplacement casing and device cannister weights recorded prior to stemming were 679,000 lb; 400,000 lb; and 183,000 lb for the top, middle, and bottom load cells, respectively. With the addition of granular stemming material, the lower gage went into compression and continued until a minimum load of 72,000 lb was reached at which time it indicated a constant load for the remainder of the operation. The load on the middle cell remained fairly constant throughout the stemming operation. The load on the top cell increased slowly until pea gravel was added to 10-3/4 in. pipe at which time the load remained constant until the final stemming with sand was begun. At this time it

increased to a maximum load of 855,000 lb. Loading data taken from the strip chart records are shown in table 1.

3.2 DISCUSSION OF RESULTS

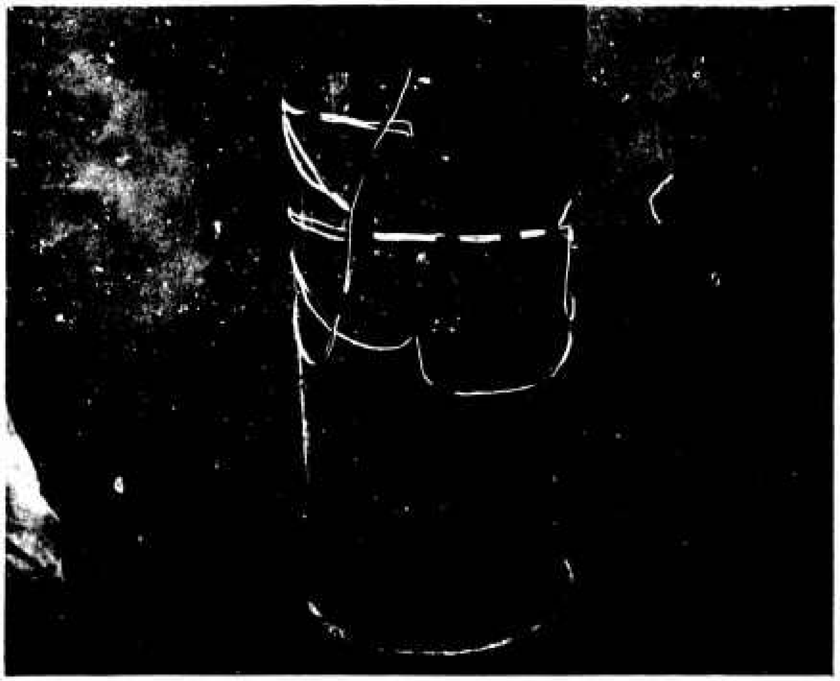
Figure 3.2 is a plot of change in load versus time as determined by the three load cells. As shown on all the curves the load dropped 90,000 to 97,000 lb when the casing was landed on the strongback. Zero load change is taken as the load immediately prior to stemming. Apparently the middle load cell did not measure a significant load change because of bridging of the sand below the middle cell. Some of the drops in loads can be attributed to the collapse of bridging. One noted in particular occurred at about 1200, 2 November 1971. This was noted at the same instant by EG&G personnel. The irregularities in the load curve of the upper load cell after 1100, 4 November 1971, can also be attributed to bridging collapse. The irregularities began occurring with final stemming with pea gravel.

CHAPTER IV

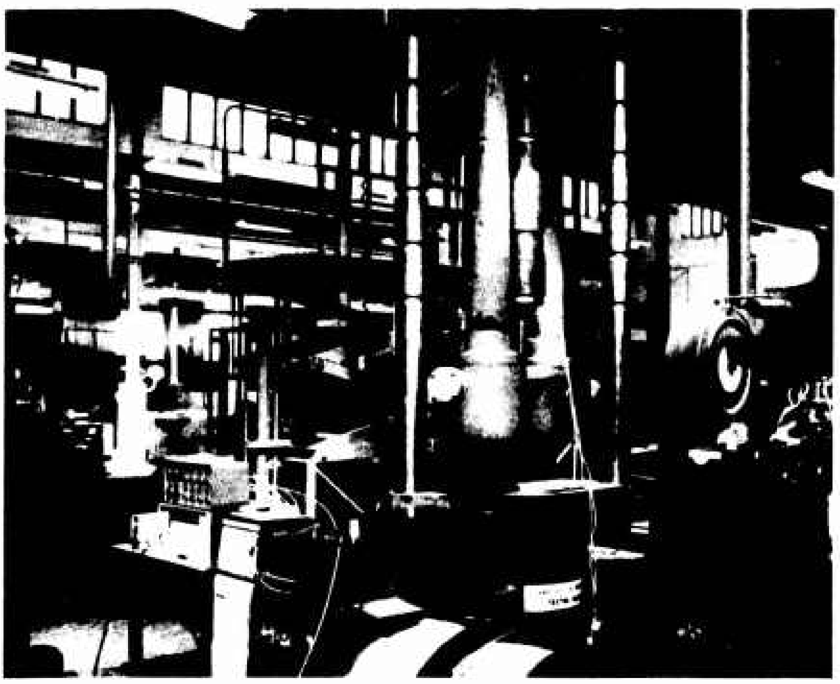
CONCLUSIONS AND RECOMMENDATIONS

The laboratory calibrated strain gaged load cells performed well in the field experiment at depths to 5305 ft. They were utilized in a special situation where a greater sensitivity was required than the original design intended. The WES equipment and personnel played an important part not only in the planned stemming operation but, also, in the downhole emplacement operation.

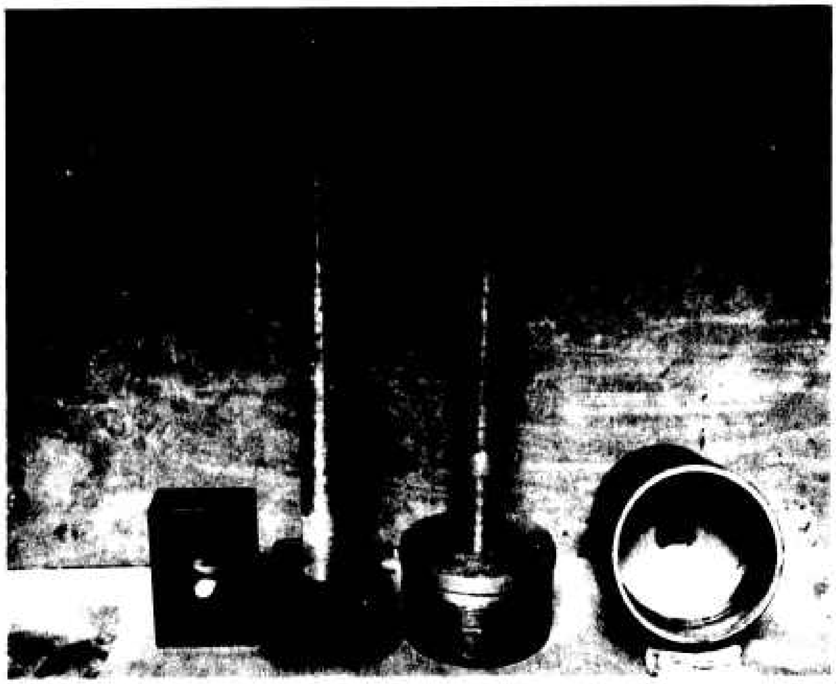
There was some concern among several LLL personnel that the WES cable was somewhat fragile for this particular experiment. Although no difficulty was encountered, LLL's concern was appreciated. It is, therefore, recommended that larger diameter and stronger cable be used for future operations.



Typical Gage Installation Around Pipe
Fig. 2.1

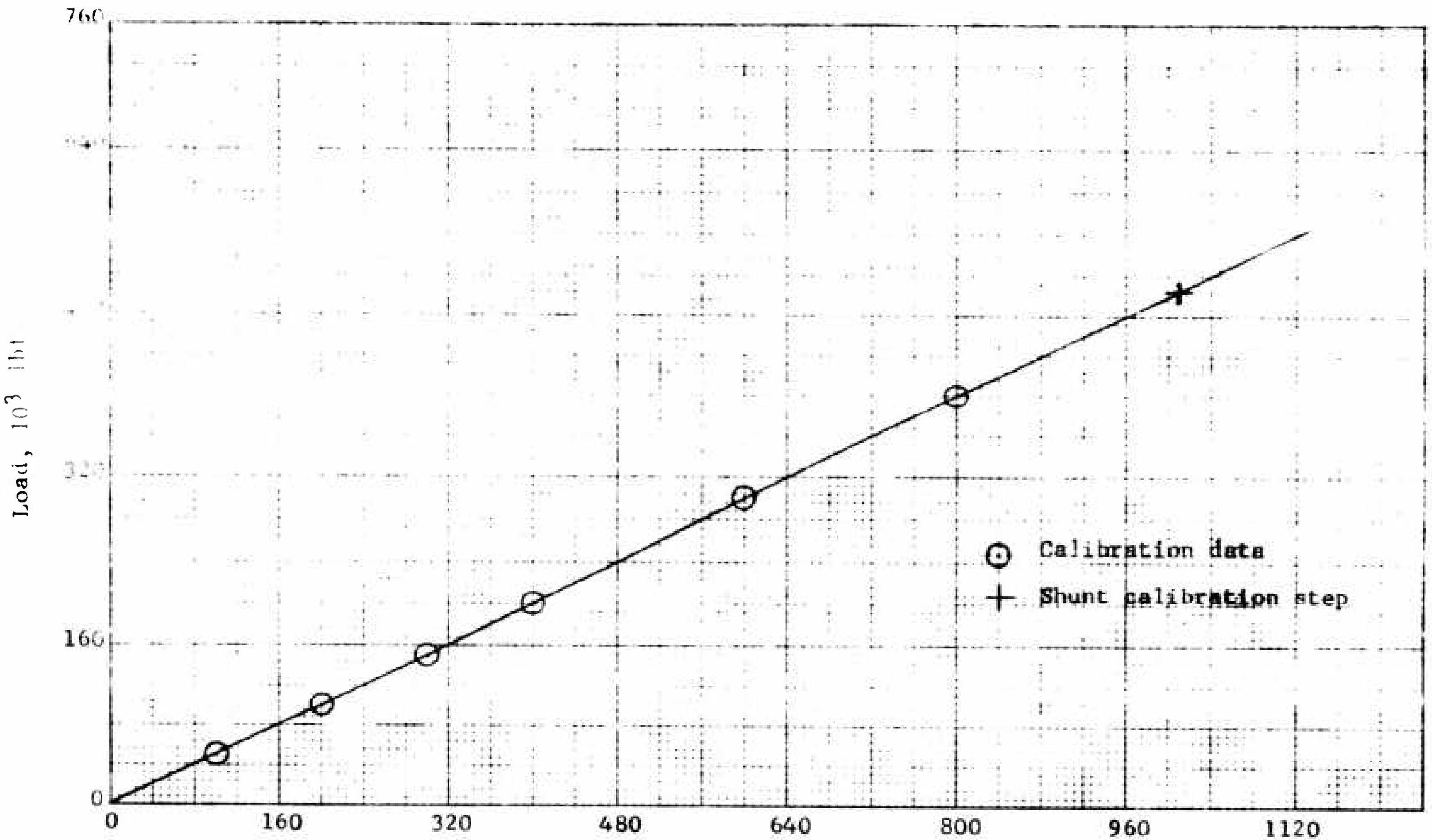


Instrumented Pup Joint in Loading Machine
Fig. 2.2



Hardware for Pull Testing Pup Joint

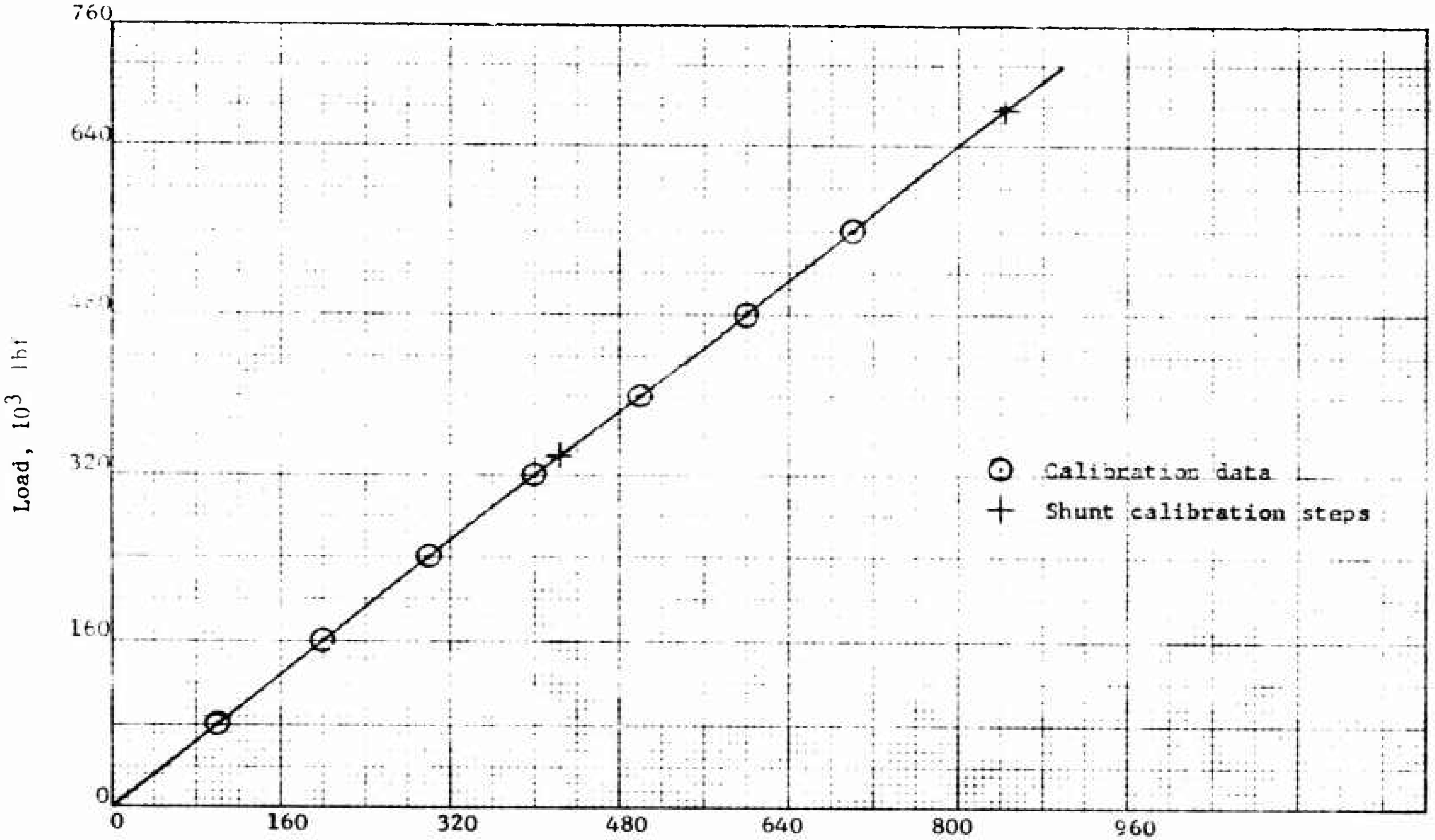
Fig. 2.3



Bridge Output, millivolts
CANNIKIN LOAD CELL CALIBRATION
Casing No. 9, Bottom 1

Fig. 2.4

WES FORM NO. 1780
JULY 1968



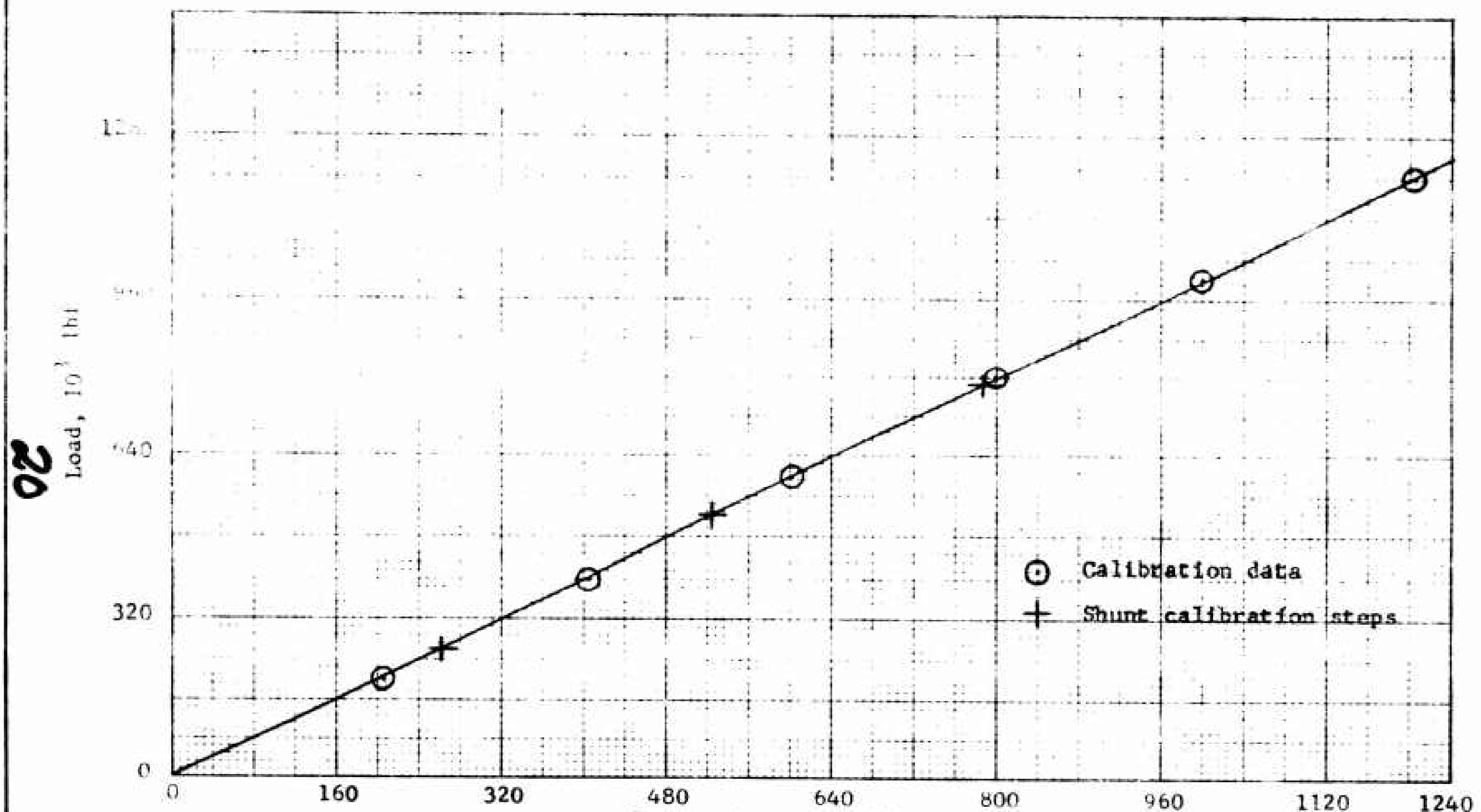
Bridge output, millivolts

CANNIKIN LOAD CELL CALIBRATION

Casing No. 15, Middle Pup Joint

Fig. 2.5

WES FORM NO. 1780
JULY 1968



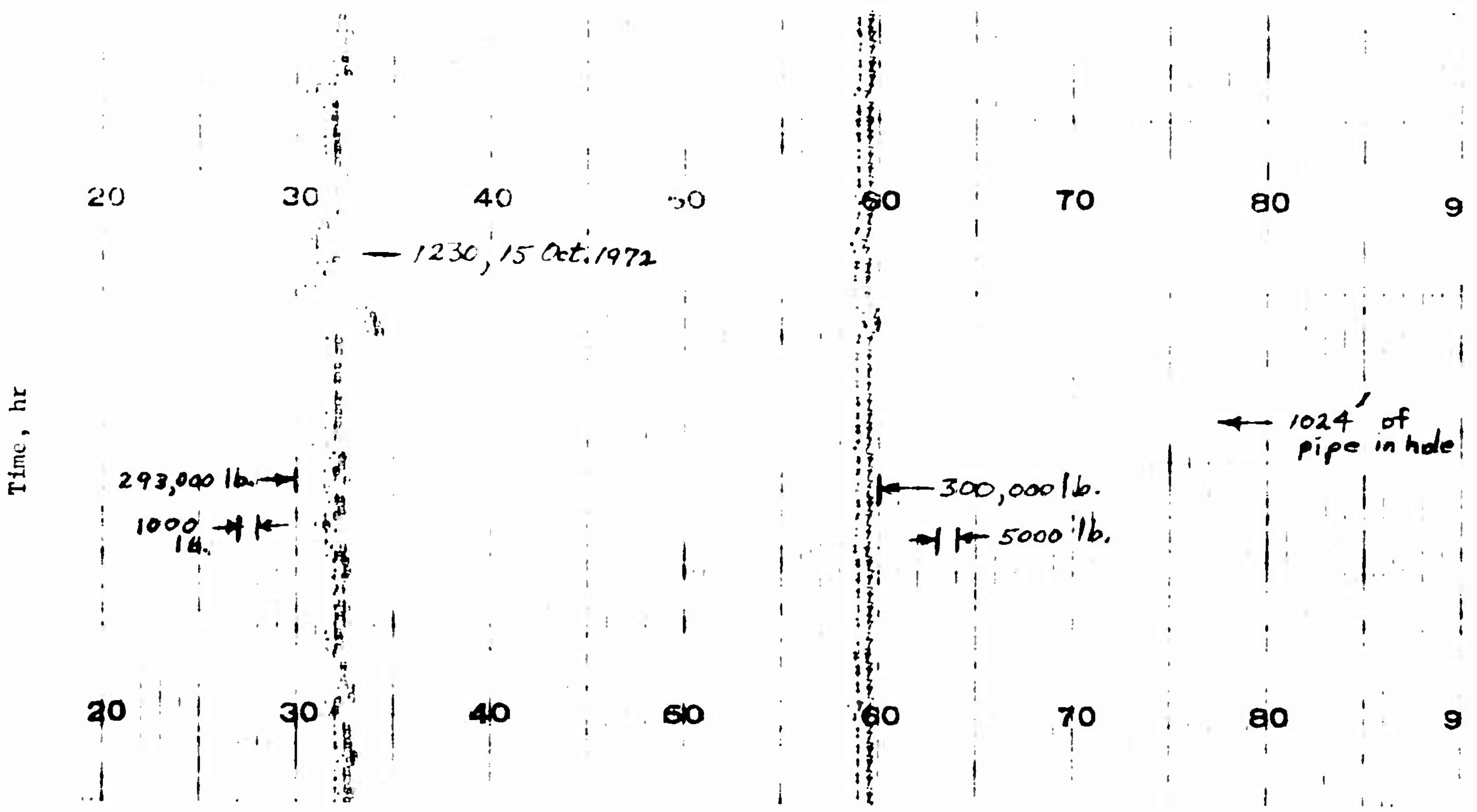
Bridge Output, millivolts

CANNIKIN LOAD CELL CALIBRATION

Casing No. 542, Top Pup Joint

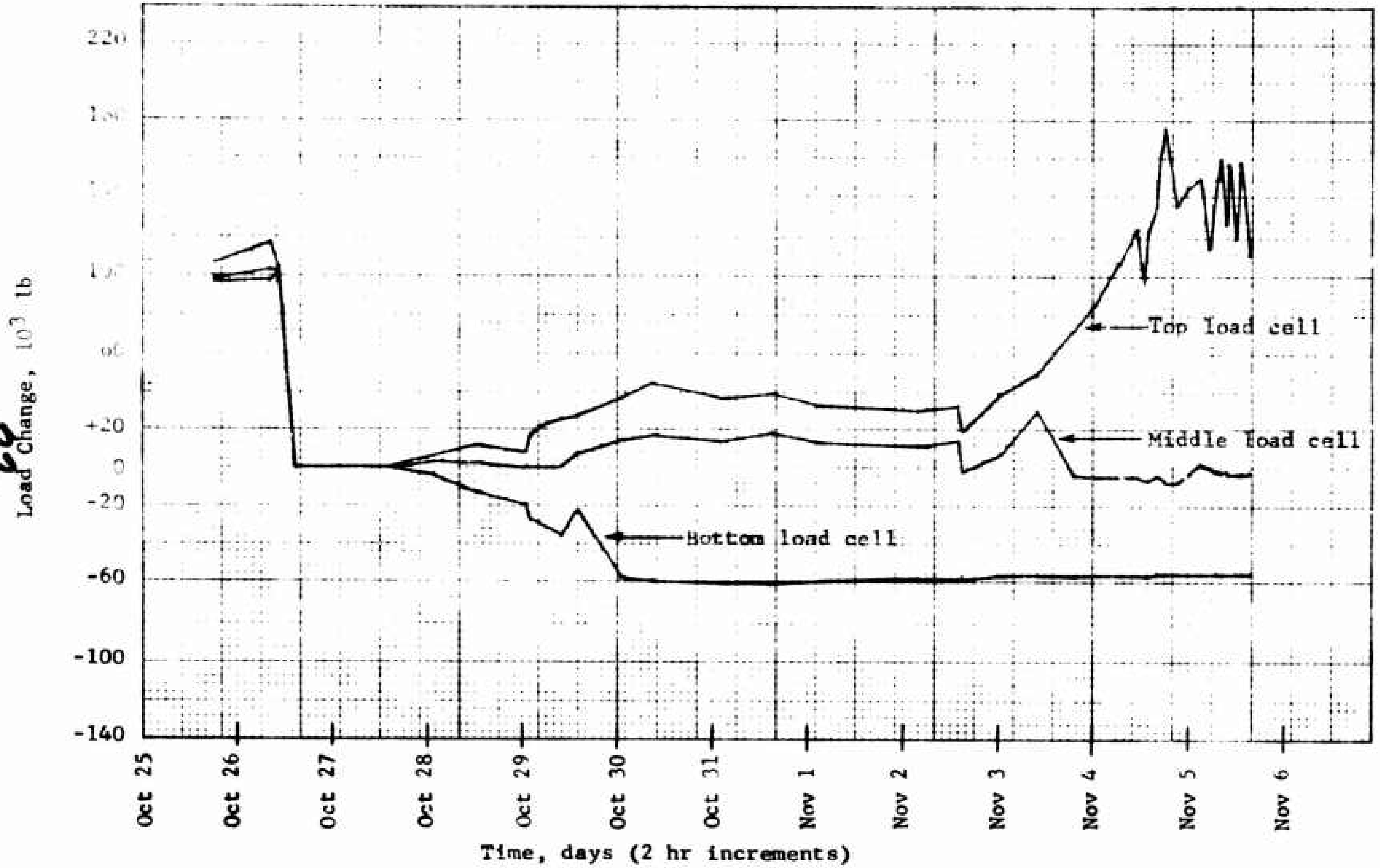
Fig. 2.6

WES FORM NO. 1780
JULY 1968



TYPICAL STRIP CHART RECORD
Load Versus Time

Fig. 3.1



CANNIKIN STEMMING HISTORY

Fig. 3.2

Table [illegible]

PROJECT [illegible] LOAD [illegible]

Date	Time	Top Load Cell		Middle Load Cell		Bottom Load Cell		Weight of Added Stemming Material and General Comments
1971		Total Load	ΔL	Total Load	ΔL	Total Load	ΔL	
Oct								
14	1045					297	114	
16	0730					295.4	112.4	
22	1435			516	+116	292	109	
23	0719			514	+114	290.3	107.3	
25	0845			508	+108	282	99	
	1820	778	+99	507	+107	280	97	
26	0830	769	+90	507	+107	277.6	94.6	
	0830	778	+99	517	+117	286.5	103.5	Lifted load and set jacks.
	1012	780	+101	518	+118	285.2	102.2	Immediately prior to removing blocks.
	1018	780	+101	504	+104	285.2	102.2	After removing blocks.
	1452	679	0	402	+2	183	0	Landed on strongback.
27	0715	679	0	400	0	183	0	Began stemming operation. Sand.
	1315	679	0	400	0	183	0	4000
	1500							5305
	1745							8350
	2020	683	+4	403	+3	181	-2	
	2205							11,600
28	0038	684	+5	402	+2	180	-3	
	0146	685	+6	403	+3	179	-4	
	0230	686	+7	402	+2	178	-5	
	0330	687	+8	402	+2	178	-5	

Load and ΔL in units of 10^3 pounds.

(Continued)

(1 of [illegible] sheets)

23.

Table 1 (Continued)

[illegible]

Date 1971	Time	[illegible] Load Cell Total Load	ΔL	[illegible] Load Cell Total Load	ΔL	[illegible] Load Cell Total Load	ΔL	Weight of Added Stemming Material and General Comments
Oct 28	0335							18,550
	0500	688	+9	402	+2	176.5	-6.5	
	0545							23,350
	0615	689	+10	402	+2	175	-8	
	0700	689	+10	402	+2	174	-9	
	0803	689	+10	402	+2	173	-10	
	0835							28,550
	0900	689	+10	403	+3	173	-10	
	1000	690	+11	403	+3	172	-11	
	1030							33,750
	1100	690	+11	403	+3	171.5	-11.5	
	1200	690	+11	403	+3	171.5	-11.5	
	1240							46,000
	1300	690	+11	403	+3	170	-13	
	1400	688	+9	401	+1	169	-14	
	1500	688	+9	400	0	167	-16	
	1525							4 cu ft/min
	1600	688	+9	400	0	165	-18	
	1700	686	+7	398	-2	164	-19	
	1800	685	+6	397	-3	163	-20	
	1900	684	+5	396	-4	163	-20	
	2000	686	+7	398	-2	163	-20	
	2100	686	+7	400	0	165	-18	
	2200	688	+9	400	0	165	-18	
	2300	688	+9	400	0	165	-18	

Load and ΔL in units of 10^3 pounds.

(Continued)

(2 of 10 sheets)

Table 1 (Continued)

PROJECT CANNIKIN STEMMING LOAD MEASUREMENTS

Date		Top Load Cell		Middle Load Cell		Bottom Load Cell		Weight of Added Stemming Material and General Comments
1971	Time	Total Load	ΔL	Total Load	ΔL	Total Load	ΔL	
Oct 28	2400	688	+9	400	0	165	-18	
Oct 29	0100	687	+8	400	0	163	-20	
Began adding magnetite								
	0200	695	+16	400	0	157.5	-25.5	
	0245	697	+18	401	+1	156	-27	
	0300	697	+18	402	+2	156	-27	
	0400	700	+21	402	+2	154	-29	
	0500	699	+20	402	+2	153	-30	
	0600	699	+20	402	+2	153	-30	
	0700	699	+20	402	+2	153	-30	
	0800	707	+28	402	+2	147.5	-35.5	
	0900	700	+21	402	+2	152	-31	
	1000	705	+26	402	+2	148	-35	
	1038	Stopped with magnetite. Began adding sand.						
	1100	710	+31	402	+2	146	-37	
	1200	700	+21	402	+2	156	-27	
	1300	701	+22	404	+4	160	-23	
	1318							80 ton/hr
	1400	706	+27	407	+7	161	-22	Shut down
	1500	707	+28	407	+7	158	-25	
	1600	707	+28	407	+7	157	-26	
	1640							
	1655							

Load and ΔL in units of 10^3 pounds.

(Continued)

Table 1 (Continued)

PROJECT CANNIKIN STEMMING LOAD MEASUREMENTS

Date	Time	Top Load Cell		Middle Load Cell		Bottom Load Cell		Weight of Added Stemming Material and General Comments
1971		Total Load	ΔL	Total Load	ΔL	Total Load	ΔL	
Oct 29	1700	707	+28	408	+8	157.5	-25.5	
	1800	709	+30	408	+8	160	-23	
	1821							
	1900	711	+32	408	+8	158	-25	
	2000	710	+31	408	+8	151	-32	
	2006							
	2100	712	+33	408	+8	146	-37	
	2107							
	2200	712	+33	409	+9	136	-47	
	2300	715	+36	412	+12	127	-56	
	2400	716	+37	414	+14	126	-57	
30	0100	716	+37	414	+14	125	-58	
	0200	717	+38	416	+16	124	-59	
	0300	719	+40	417	+17	124	-59	
	0400	720	+41	416	+16	123	-60	
	0500	718	+39	416	+16	125	-60	
	0600	720	+41	418	+18	123	-60	
	0700	720	+41	419	+19	122.8	-60.2	
	0800	725	+46	423	+23	123	-60	
	0900	724	+45	417	+17	123	-60	
Began stemming with pea gravel in 10-3/4 in. pipe								
	0925							17,300 lb
	1000	720	+41	419	+19	120	-63	
	1100	719	+40	418	+18	120	-63	
	1200	719	+40	418	+18	121	-63	

Load and ΔL in units of 10^3 pounds.

(Continued)

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Table 1 (Continued)

PROJECT CANNIKIN STEMMING LOAD MEASUREMENTS

Date	Time	Top Load Cell		Middle Load Cell		Bottom Load Cell		Height of Added Stemming Material and General Comments
1971		Total Load	ΔL	Total Load	ΔL	Total Load	ΔL	
Oct 30	1300	720	+41	418	+18	122	-63	
	1400	720	+41	418	+18	122	-63	
	1500	720	+41	416	+16	122	-62	
	1600	718	+39	415	+15	122	-62	
	1700	718	+39	416	+16	122	-62	
	1800	718	+39	416	+16	122	-62	
	1900	718	+39	416	+16	122	-62	
	2000	718	+39	416	+16	122	-61	
	2100	718	+39	415	+15	122	-61	
	2200	718	+39	414	+14	122	-61	
	2300	716	+37	414	+14	122	-61	
	2400	715	+36	412	+12	122	-61	
31	2400	715	+36	412	+12	122	-61	
Change from daylight to standard time								
	0100	715	+36	412	+12	122	-61	
	0200	715	+36	412	+12	122	-61	
	0245	Began stemming annulus with pea gravel						
	0300	716	+37	414	+14	122	-61	
	0400	716	+37	415	+15	122	-61	
	0500	718	+39	415	+15	122	-61	
	0600	718	+39	414	+14	122	-61	
	0700	718	+39	414	+14	122	-61	
	0800	718	+39	414	+14	122	-61	
	0900	718	+39	416	+16	122	-61	

Load and ΔL in units of 10^3 pounds.

(Continued)

(5 of 10 sheets)

Table 1 (Continued)

PROJECT CANNIKIN STEMMING LOAD MEASUREMENTS

Date	Time	Top Load Cell		Middle Load Cell		Bottom Load Cell		Weight of Added Stemming Material and General Comments
1971		Total Load	ΔL	Total Load	ΔL	Total Load	ΔL	
Oct 31	1000	718	+39	416	+16	122	-61	
	1100	718	+39	418	+18	122	-61	
	1159							
	1200	718	+39	418	+18	122	-61	
	1243							
	1300	718	+39	418	+18	122	-61	
	1340							
	1348							
	1400	718	+39	418	+18	122	-61	
	1500	718	+39	418	+18	122	-61	Poured plastic plug
	1600	718	+39	418	+18	122	-61	
	1700	718	+39	417	+17	122	-60	
	1800	715	+36	414	+14	122	-60	
	1900	712	+33	412	+12	122	-60	
	2000	712	+33	412	+12	122	-60	
	2100	712	+33	412	+12	123	-60	
	2200	712	+33	412	+12	123	-60	
	2300	711	+32	412	+12	123	-60	
Nov 1	0100	712	+33	413	+13	123	-60	
	0300	711	+32	411	+11	124	-59	
	0500	711	+32	411	+11	124	-59	
	0700	710	+31	411	+11	124	-59	
	0900	710	+31	411	+11	124	-59	
	1100	712	+33	413	+13	123.5	-59.5	

28.

Load and ΔL in units of 10^3 pounds.

(Continued)

Table _ (Continued)

PROJECT CANNIKIN STEMMING LOAD MEASUREMENTS

Date		Top Load Cell		Middle Load Cell		Bottom Load Cell		Weight of Added Stemming Material and General Comments
1971	Time	Total Load	ΔL	Total Load	ΔL	Total Load	ΔL	
Nov 1	1300	713	+34	416	+16	124	-59	
	1400	706	+27	408	+8	124	-59	
	1500	703	+24	406	+6	124.8	-58.2	
	1600	703	+24	406	+6	124.8	-58.2	
	1652	703	+24	406	+6	124	-59	
	2000	707	+28	409	+9	124	-59	
	2400	709	+30	410	+10	124	-59	
2	0400	709	+30	411	+11	124	-59	
	0700	710	+31	411	+11	124.5	-58.5	
	0900	710	+31	412	+12	124.5	-58.5	
	1100	710	+31	413	+13	124.5	-58.5	
	1200	712	+33	414	+14	124.5	-58.5	
	1300	712	+33	414	+14	124.5	-58.5	
	1400	712	+33	414	+14	124.5	-58.5	
	1500	698	+19	398	-2	124.5	-58.5	
	1505	Void collapse - EG&G Lights came on				124	-59	
	1512					125	-58	
	1700	697	+18	397	-3	125	-58	
	1900	702	+23	402	+2	125.5	-57.5	
	2200	707	+28	406	+6	125.5	-57.5	
	2400	709	+30	407	+7	125.5	-57.5	
3	0100	708	+29	407	+7	126	-57	
Began stemming at ~ 0100								
	0200	712	+33	410	+10	126	-57	
	0300	715	+36	414	+14	126	-57	

Load and ΔL in units of 10^3 pounds.

(Continued)

Table 1 (Continued)

PROJECT CANNIKIN STEMMING LOAD MEASUREMENTS

Date		Top Load Cell		Middle Load Cell		Bottom Load Cell		Weight of Added Stemming Material and General Comments
1971	Time	Total Load	ΔL	Total Load	ΔL	Total Load	ΔL	
Nov 3	0400	715	+36	415	+15	126	-57	
	0500	718	[illegible]	416	+16	126	-57	
	0600	718	+39	416	+16	126	-57	
	0700	720	+41	421	+21	126	-57	
	0800	722	+48	423	+23	126	-57	
	0900	726	+47	426	+26	126	-57	
	1000	729	+50	430	+30	126.5	-56.5	
	1100	729	+50	430	+30	126.5	-56.5	
	1200	730	+51	430	+30	126.5	-56.5	
	1300	734	+55	433	+33	126.5	-56.5	
	1410	736	+57	438	+38	127	-56	
	1500	738	+59	438	+38	126	-57	
	1600	740	+61	438	+38	126	-57	
	1700	741	+62	414	+14	126	-57	
	1800	748	+69	400	0	126	-57	
	1900	750	+71	396	-4	126	-57	
	2000	752	+73	396	-4	126	-57	
	2100	755	+76	396	-4	126	-57	
	2200	759	+80	396	-4	126	-57	
	2300	761	+82	395	-5	126	-57	
	2400	761	+82	395	-5	126	-57	
4	0100	765	+86	395	-5	126	-57	
	0200	768	+89	395	-5	126	-57	
	0300	775	+96	395	-5	126	-57	
	0400	781	+102	395	-5	126	-57	
	0500	781	+102	395	-5	126	-57	

Load and ΔL in units of 10^3 pounds.

(Continued)

Table 1 (Continued)

PROJECT CANNIKIN STEMMING LOAD MEASUREMENTS

Date		Top Load Cell		Middle Load Cell		Bottom Load Cell		Weight of Added Stemming Material and General Comments
1971	Time	Total Load	ΔL	Total Load	ΔL	Total Load	ΔL	
Nov 4	0600	782	+103	395		126	-57	
	0700	786	+107	395		126	-57	
	0800	791	+112	395		126	-57	
	0900	795	+116	395		126	-57	
	1000	798	+119	395		126	-57	
	1100	803	+124	395		126	-57	
Began stemming with pea gravel								
	1200	798	+119	395		126	-57	
	1215	790	+111					
	1230	792	+113					
	1245	780	+101					
	1252	775	+96					
	1300	778	+99	394	-6	126	-57	
	1400	802	+123	394	-6	126	-57	
	1430	810	+131					
	1445	813	+134					
	1500	802	+123	395	-5	126.5	-56.5	
	1515	795	+116					
	1530	802	+123					
	1600	814	+135	395	-5	126.5	-56.5	
	1700	838	+159	394	-6	126.5	-56.5	
	1800	854	+175	393	-7	126.5	-56.5	
	1900	842	+163	393	-7	126.5	-56.5	
	2000	825	+146	393	-7	126.5	-56.5	
	2100	815	+136	393	-7	127	-56	

Load and ΔL in units of 10^3 pounds.

(Continued)

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Table 1 (Concluded)

PROJECT CANNIKIN STEMMING LOAD MEASUREMENTS

Date		Top Load Cell		Middle Load Cell		Bottom Load Cell		Weight of Added Stemming Material and General Comments
1971	Time	Total Load	ΔL	Total Load	ΔL	Total Load	ΔL	
Nov 4	2200	822	+143	393	-7	127	-56	
	2300	819	+140	396	-4	127	-56	
	2400	824	+145	397	-3	127	-56	
5	0100	832	+153	397	-3	127	-56	
	0200	822	+143	398	-2	127	-56	
	0300	828	+149	402	+2	127	-56	
	0400	822	+143	400	0	127	-56	
	0500	792	+113	400	0	127	-56	
	0600	813	+134	401	+1	127	-56	
	0700	828	+149	398	-2	127	-56	
	0800	838	+159	398	-2	127	-56	
	0930	806	+127	398	-2	127	-56	
	1000	826	+147	397	-3	127	-56	
	1100	836	+157	397	-3	127	-56	
	1124	830	+151					
	1133	768	+89					
	1200	799	+120	397	-3	127	-56	
	1300	837	+158	397	-3	127	-56	
	1400	805	+126	397	-3	127	-56	
	1500	790	+111	397	-3	127	-56	
	1515	791	+112	397	-3	127	-56	

Load and ΔL in units of 10^3 pounds.

(10 of 10 sheets)

In accordance with ER 70-2-3, paragraph 6c(1)(b), dated 15 February 1973, a facsimile catalog card in Library of Congress format is reproduced below.

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